APPLICATION UNDER UNITED STATES PATENT LAWS

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Invention: SUSPENSION SYSTEM WITH MAGNETIC RESILIENCY

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This is a:

☐ Provisional Application

☒ Regular Utility Application

☐ Continuing Application
☐ The contents of the parent are incorporated by reference

☐ PCT National Phase Application

☐ Design Application

☐ Reissue Application

☐ Plant Application

☐ Substitute Specification
Sub. Spec Filed ____________
in App. No. ___/_________

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Sub. Spec. filed ____________
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SPECIFICATION

SUSPENSION SYSTEM WITH MAGNETIC RESILIENCY

BACKGROUND OF THE INVENTION

[0001] This application claims priority to US provisional application No. 60/396,634, the entire contents of which is hereby incorporated by reference.

1. Field of the Invention

[0002] The invention relates to suspension systems in general, and more particularly, to suspension systems for motor vehicles.

2. Description of Related Art

[0003] Motor vehicle suspension systems are designed to absorb vibrational forces using a resilient member, such as a coil spring, and then dissipate those forces using a damping device, such as a shock absorber. The coil spring, or other resilient member, also biases the vehicle tires to maintain firm contact with the road.

[0004] A typical type of vehicle suspension system includes an assembly in which a shock absorber is coaxially mounted within a coil spring, such that the coil spring and the shock absorber act in parallel against the reaction forces of the vehicle tires against the road. The coil spring may be either a cylindrical coil spring, so as to provide an essentially constant compliance, or barrel shaped, so as to provide a compliance that varies with the displacement of the spring. In a typical suspension system, one spring/coil assembly is coupled to each wheel.

[0005] The design of the suspension system is a compromise between passenger comfort and vehicle handling concerns, as well as overall vehicle design constraints. For example, the use of softer, more compliant springs adds to passenger comfort, but compliant springs are typically longer in length, which may raise the vehicle body height. Therefore, in some designs, auxiliary air or hydropneumatic springs are used in addition to a relatively compliant primary coil spring. The use of the auxiliary air or hydropneumatic spring allows the suspension system to be designed such that the vehicle body remains relatively close to the ground, despite the longer length of the more compliant spring. However, the use of an auxiliary spring, in addition to the primary coil spring and a shock absorber, makes the suspension system more complex and

more costly. Additionally, a more compliant spring may be more susceptible to damage under harsh driving conditions.

[0006] More complex, adaptive suspension systems are sometimes installed in racing vehicles and high-end mass-market motor vehicles, such as luxury sedans. These adaptive motor vehicle suspension systems may include means to adaptively control the damping level and the resiliency of the suspension system by using a hydraulic or electromechanical actuator to replace the typical coil spring and shock absorber. Adaptive systems, while allowing more control over the vehicle, are typically more expensive.

[0007] U.S. Patent No. 3,770,290 to Bottalico discloses an alternative suspension system more suitable for lower-end mass-market motor vehicles. In the suspension system of this reference, a set of permanent magnets or electromagnets serves as the resilient member and/or the damping member. The magnets of this suspension system are mounted in housings that are spaced vertically from one another and are maintained in coaxial relationship by a central guide or post. Like magnetic poles of the two magnets are positioned opposite each other such that they create magnetic forces of repulsion. However, the reference does not disclose how such a magnetic suspension system might be combined with other conventional suspension components, such as shocks and struts.

SUMMARY OF THE INVENTION

[0008] In one aspect, the present invention provides a vehicle suspension system. The vehicle suspension system includes a damping device and first and second magnetic structures.

[0009] The damping device has first and second opposite portions moveable in opposite directions toward and away from one another. The first portion of the damping device is adapted to be coupled to a motor vehicle frame and the second portion of the damping device is adapted to be coupled to a motor vehicle wheel mount structure such that the damping device is adapted to dampen movement of the first and second portions toward or away from one another.

[0010] The first and second magnetic structures of the vehicle suspension system are connected to the first portion and second portion, respectively. The arrangement of like magnetic

poles of the two magnetic structures creates a resilient magnetic bias sufficient to repel the first and second opposite portions during a relative movement of the portions toward one another.

BRIEF DESCRIPTION OF THE DRAWING

[0011] Embodiments of the present invention will be described with reference to the following drawing, in which:

[0012] Figure 1 is a schematic sectional view of a suspension system with magnetic resiliency according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0013] An embodiment of a suspension system with magnetic resiliency is illustrated in the schematic sectional view of FIGURE 1. The suspension system, generally indicated at reference numeral 10, includes a damping device 12, first and second magnetic structures 14, 16 and a sleeve 32. In the following description, it should be understood that certain directional references (e.g., "vertical," "horizontal," "top," "bottom," "upper," "lower") are made with respect to the coordinate system of FIGURE 1, and may vary in an actual installation or use of suspension system 10.

[0014] In general, a damping device used as a component of suspension system 10 has opposite portions moveable in opposite directions toward and away from each other and is configured to dampen movement of those opposite portions in a direction toward or away from one another. The damping device 12 has a first portion 18 with an upper mount structure 20 and a second portion 22 with a lower mount structure 24. In damping device 12, the upper mount structure 20 is provided at the upper end of the first portion 18 and the lower mount structure 24 is provided at the lower end of the second portion 22. In other embodiments of suspension system 10, the upper and lower mount structures 20, 22 need not be provided at respective ends of the damping device. Instead, the mount structures 20, 22 could be disposed at any point along the first and second portions 18, 22, respectively, of the damping device 12, as appropriate to connect to the other components of suspension system 10.

[0015] In the embodiment illustrated in FIGURE 1, the damping device 12 is a conventional shock absorber, which may be of single-tube or twin-tube design. However, the

damping device 12 may also be a strut or another conventionally known suspension damping member.

[0016] The upper mount structure 20 on the first portion 18 of the damping device 12 may be adapted for connection to the upper control arm of the motor vehicle if the suspension system 10 is mounted between upper and lower control arms, or it may be adapted for connection to the vehicle frame if the suspension system 10 is mounted between the upper control arm and the vehicle frame. Similarly, the lower mount structure 24 on the second portion 20 of the damping device 12 may be adapted for connection to the lower control arm of the motor vehicle if the suspension system 10 is mounted between upper and lower control arms, or it may be adapted for connection to the upper control arm if the suspension system 10 is mounted between the upper control arm and the vehicle frame. The motor vehicle is not shown in FIGURE 1. With the upper and lower mount structures 20, 24 mounted to appropriate motor vehicle structures, the damping device 12 is arranged to dissipate at least a portion of a force applied to the damping device 12 along a line of action L that extends between the first portion 18 and the second portion 22. More generally, the damping device 12 dampens movement of the first portion 18 and the second portion 22. For example, to dissipate or dampen a compressive force applied to the damping device 12 along the line of action L, the first and second portions 18, 22 of the damping device 12 would move toward one another.

[0017] A first magnetic structure 14 is mounted on the first portion 18 of the damping device 12, and a second magnetic structure 16 is mounted on the the second portion 22 of the damping device 12. In the embodiment of FIGURE 1, the two magnetic structures 14, 16 are annularly shaped permanent magnets. Each of the annular magnetic structures 14, 16 is provided with a central hole 26 of sufficient diameter to receive the exterior surface of the damping device 12, and each is secured to the exterior surface of the damping device 12 by appropriate means (e.g., adhesives or mechanical fasteners such as bolts). In this way, the first and second magnetic structures 14, 16 are maintained in coaxial alignment with one another. The central axis of the two magnetic structures 14, 16 coincides with the line of action L.

[0018] The two magnetic structures 14, 16 are arranged on the damping device 12 such that surfaces having like magnetic poles (e.g., surfaces 28 and 30 in FIGURE 1) are adjacent to and oppose one another, creating magnetic forces of repulsion, and thus, causing a resilient

magnetic bias. In the arrangement of FIGURE 1, the resilient magnetic bias acts to move the first and second portions 18, 22 of the damping device 12 away from one another. The resilient magnetic bias created by the first and second magnetic structures 14, 16 allows the suspension system 10 to absorb at least a portion of a force applied along line of action L and dampen movement of the suspension system.

[0019] Although the first and second magnetic structures 14, 16 illustrated in FIGURE 1 are annular in shape, magnetic structures according to the invention need not be annular in shape. In addition, the two magnetic structures 14, 16 need not be contiguous over the outer circumference of the damping device 12. For example, the two magnetic structures 14, 16 could be rectangular in shape, or given any other polygonal shape (e.g., rectangular, pentagonal, hexagonal) of sufficient size to receive the damping device 12 (e.g., using hole 26 as illustrated in FIGURE 1). Alternatively, the two magnetic structures 14, 16 may comprise two pluralities of individual magnets, the two pluralities of magnets disposed, respectively, on the first and second portions 18, 22 of the damping device 12, with each of the individual magnets spaced circumferentially from the others about the outer circumference of the damping device 12. The use of two pluralities of individual magnets as the first and second magnetic structures 14, 16 would be particularly useful when, for example, the damping device 12 is non-cylindrical, or has an outer surface for which it would be difficult or inconvenient to manufacture a magnet with a corresponding hole 26 to receive the damping device 12. The use of two pluralities of individual magnets as the first and second magnetic structures 14, 16 would also be useful if the characteristics of a particular magnet make it unfeasible to machine or otherwise create a hole 26 in the magnet. In the embodiment illustrated in FIGURE 1, it is preferable if the two magnetic structures 14, 16 are positioned in coaxial alignment, and if two pluralities of magnets are used, it is preferable that the individual magnets of each plurality are positioned generally in alignment with corresponding individual magnets of the other plurality of magnets.

[0020] The damping device 12 with attached first and second magnetic structures 14, 16 is received in an outer structure such as sleeve 32. The outer surfaces 36, 38 of the first and second magnetic structures 14, 16 are adapted to slidingly engage an interior bearing surface 34 of the sleeve 32 so as to provide a fluid-tight seal between the outer surfaces 36, 38 of the magnetic structures 14, 16 and the interior bearing surface 34 of the sleeve 32 (i.e., as in a

piston-cylinder relationship). The bearing surfaces 34, 36, 38 may be provided with appropriate lubrication to prevent wear, or additional sealing structure (e.g., gaskets or O-rings) to facilitate the seal. The fluid-tight sliding engagement of the two magnetic structures 14, 16 within the sleeve 32 isolates the interior cavity of the suspension system 10. This interior cavity is generally indicated by reference numeral 40 in FIGURE 1. If additional resiliency is desired in the suspension system 10, the interior cavity 40 may be filled with a pressurized gas. The pressurized gas in the interior cavity 40 would act as a pneumatic spring, providing a pneumatic resilient force as the first and second magnetic structures 14, 16 are forced towards one another by forces applied to the suspension system 10.

[0021] The sleeve 32 also isolates the first and second magnetic structures 14, 16 and damper 12 and protects them from the road conditions to which the vehicle is exposed. In particular, the sleeve 32 may prevent the components from being damaged by small rocks, stones or other road particles that might be propelled into the suspension during driving. The sleeve 32 includes rubber boots 42 to assist in mounting the suspension system 10 to a motor vehicle and to absorb minor vibrations. Depending on the mounting of suspension system 10, rubber boots 42 may also be provided at the upper end to absorb minor vibrations.

[0022] In the suspension system 10 illustrated in FIGURE 1, the magnetic structures 14, 16 are attached to the damping device 12, and thus have a restricted range of travel based on the range of travel of the damping device 12. The actual spacing of the two magnetic structures 14, 16 with respect to the damping device 12 may be varied to achieve an optimum range of travel, and also to maintain a desired level of repulsive magnetic bias between the first and second magnetic structures 14, 16. Additionally, horizontally-extending stops or endcaps may be installed on the sleeve 32 to restrict the range of travel of the damping device 12 and the magnetic structures 14, 16. If individual pluralities of magnets are used as the first and second magnetic structures 14, 16 as described above, the endcaps may be used to make a fluid-tight seal with the bearing surface 34 of the sleeve 32.

[0023] In certain embodiments, the sleeve 32 may not slidingly engage the two magnetic structures 14, 16, and instead, may merely contain the damping device 12 and magnetic structures 14, 16 and protect those components, as described above. The sleeve 32 and damping device 12 may be made of any non-magnetic material.

[0024] Although the invention has been described with respect to certain embodiments, it will be realized that alterations, modifications, and additions will occur to those skilled in the art and may be made without departing from the spirit of the invention. The full scope of the invention is defined by the appended claims.